TROPICAL AGRICULTURE

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THE IMPERIAL COLLEGE OF TROPICAL AGRICULTURE, TRINIDAD, B.W.I.

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TROPICAL AGRICULTURE is published monthly at the Imperial College of Tropical Agriculture, St. Augustine, Trinidad, West Indies. Advertisement and subscription rates can be obtained at the College from the Editor, or from the Secretary of the College, Broadway Bldgs., Westminster, S.W. 1, England. The Editor will be glad to consider authoritative articles for publication. It is understood that opinions expressed or recommendations made in signed articles or in articles of which the source is named are those of the author and do not necessarily represent the policy or opinion of the College Authorities. Increasing numbers of inquiries are being received from the various parts of the tropics which can be answered only by persons possessed of an intimate knowledge of local conditions. Enquirers should first satisfy themselves that their local Department of Agriculture is not able to supply them with the desired information before communicating with us. Correspondence which will be replied to is invited on all other matters pertaining to tropical agriculture, science and development.

AT RANDOM.

The College.

IT will be remembered that some apprehension was felt at the outbreak of war in regard to the immediate future of the College. The events of the past year, however, have clarified our position considerably. It is evident that the British Government attaches considerable importance to the continuation of our functions because of their direct bearing on the development of agriculture in the Colonial Empire. Our work, accordingly, is proceeding normally and, in the existing circumstances, is likely to become of increasing rather than decreasing importance. We have also been assured that by remaining at their posts, the members of our staff are making the fullest contribution they can to the national effort. The most stringent economy, consistent with the proper carrying out of the approved programme of teaching and research is, however, being exercised and everything possible is being done leading to economy in our administration. Various reductions in expenditure have already been effected in ways that cause little interference with our main lines of work. Our sources of revenue, on the other hand, appear for the present at least to be assured for some time to come and we will, therefore, be able to preserve the continuity of our research work and to maintain all our services.

The arrival of Sir Frank Stockdale, Comptroller for Development and Welfare in the West Indies and of Mr. A. J. Wakefield, the new Inspector-General of Agriculture heralds new developments in which the College is bound to play an important part. The recommendations made by the West India Royal Commission point to a considerable expansion of our work and duties. It will be some time, however, before definite lines of policy can be formulated and we can only conjecture that we will be called upon to do our share in any long term programmes of agricultural development in the West Indies that may be decided upon.

Staff Changes.

Since the outbreak of war there have been few staff changes. Dr. Wardlaw resigned in September last to become Barker Professor of Cryptogamic Botany at Manchester University. Mr. Leonard is acting as Officer in charge of the Low Temperature Research Station. Dr. Dickson resigned at the end of last year and is succeeded

by Dr. Mary Gianetti who has been appointed part-time Health Officer. Mr. Crowdy, Lecturer in Mycology, was released from National Service to resume his duties at the College.

Dr. Wardlaw is to be heartily congratulated on his new appointment at Manchester University. He first joined the College in 1928 as Plant Pathologist for Banana Research. His extensive researches into the diseases of the banana culminated in the production of what must be regarded as the standard book of reference on the subject. Thereafter, Dr. Wardlaw directed his attention mainly to physiological problems in relation to the refrigeration and transport of tropical fruits and vegetables. He threw himself wholeheartedly into this work and it is largely due to his energy, enthusiasm and breadth of outlook that the Station, of which he was head and which he directed so ably for so many years has built for itself the reputation which it now enjoys in other parts of the British Empire. Dr. Wardlaw's departure is a great loss to the College and his valuable services in all sorts of capacities will be greatly missed, for he was interested in many other aspects of College work. We wish him every success in his new sphere of activities and are confident that he will make full use of the opportunities offered by the Chair which he now occupies.

The news of Sir Algernon Aspinall's resignation from the post of Secretary of the College which has reached us, just as we go to press, will be received with much regret by all members of the staff. Sir Algernon's association with this institution dates back to its foundation, for he joined the Tropical Agricultural College Committee in 1919 and was appointed Secretary of the West Indian Agricultural College, as the College was then known, at the first meeting of the Governing Body on the 21st September, 1921. Sir Algernon, who has thus been with us for more than 20 years, was always enthusiastically interested in our development and work. As Secretary he displayed rare gifts of tact, initiative and business ability, while his extensive knowledge of West Indian affairs was of much help to this institution. Although Sir Algernon has resigned, we are glad to learn that pending the appointment of a successor, he will continue to serve as Consultant to the Governing Body.

Our best wishes go with him in his retirement, and we hope that he will enjoy the very best health and much happiness for many years to come.

The New Session 1940-41.

The new session opened normally this year and is now well under way. A full class of First-Year Diploma students has been admitted. They have been warned that it may not be possible for them to complete their studies; but the chances at the moment of their not being able to qualify appears to be remote since the College will almost certainly be able to carry on until 1943. If it does not, arrangements will be made for these men to continue their training as soon as possible after war is over. There are at present 37 students taking the Diploma course. Of these one comes from Hong-Kong, three from Columbia, two from Venezuela and the remainder from the British West Indies.

Eight Colonial Office cadets and two Sudan Government scholars arrived some time before the session started, and one more Colonial cadet arrived recently. We also welcome, for the first time, four scholars sent by the Burmese Government. They arrived safely after a journey of some two months. These men are taking the Associateship course. In addition, another batch of 11 Colonial office cadets is expected to arrive at the end of the year. These men normally would have spent the first year of their training at Cambridge University but the Colonial Office, in the present circumstances, have decided to send them straight out to Trinidad for the whole two years. A new Associateship course covering a period of two years has accordingly had to be arranged for them. Preparations are now well under way to receive these cadets; but the change of policy will throw much additional work on the professorial staff who will this session have to teach two entirely separate post-graduate courses, one of which has to be newly designed to meet the needs of the two-year men. We hope, however, that this new two-year course will prove a great success. When the second batch of cadets arrive the total number of students in residence will be 66, a figure which is above any recorded so far for the College.

HORMONES AND THE GARDEN

The discovery of growth-promoting compounds in plants brought new opportunities of horticultural propagation. Marked stimulation in the rooting of cuttings of many species can be brought about, but a curious crop of failures has still to be explained. M. A. H. Tinckler, with the assistance of C. H. Unwin, has studied the action of a number of such substances upon a wide range of plants which can be propagated by cuttings. Their most recent results (*J. Roy. Hort. Soc.*, 64, Pt. 12) indicate that sixty-one species of those which were tried propagate more readily with treatment, whilst twenty-nine species still defy the propagator. The growth-promoting substances can be mixed with talc and applied satisfactorily in powder form—a great convenience. Vitamin B1 (aneurin) alone did not appear to stimulate rooting, but it did increase the percentage of rooted cuttings in a third of the total experiments. The most valuable substances for propagation were found to be (1) indolylbutyric acid, (2) tetrahydro-naphthylideneacetic acid, and (3) a mixture of (2) with 3 : 4-dihydro-1-naphthylacetic acid. Some species responded to (1), and others to (2), with equal effect, and the behaviour of (3) approximated closely to (2). The paper gives numerous results of the individual calibre which is urgently needed in this new practice of scientific horticulture.—(*Nature*, Vol. 145, No. 3664, 1940, pp. 112-113.)

A REVIEW OF CACAO SELECTION IN THE CAMEROONS.

By O. J. Voelcker.
(*Department of Agriculture, Nigeria*)

[*The information published in this article was obtained from Herr E. Mylord who was responsible for planning and carrying out the selection work.*—Editor.]

During a recent visit to the British Mandated Territory of the Cameroons, Mr. J. West, Supervisor of the German Plantations, brought to my notice the fact that Herr Mylord, Manager of the Westafrikanische Pflanzungs-Gesellschaft "Victoria"—(W.A.P.V.)—had a mass of data relating to his work on cacao selection. Herr Mylord gave me all the figures he had obtained, and I suggested that certain of these were of sufficient scientific interest to warrant publication. To this he agreed.

In 1930, the W.A.P.V. estate was still engaged in planting up fields of cacao. The usual practice adopted in the choice of seed was to pick out large red pods from the heaps after harvesting. It was at that time generally assumed that trees with large red pods gave larger beans and a greater yield of wet cacao, and that such pods were less susceptible to "Black Pod" disease. Mylord queried both these assumptions. He therefore set about accumulating sufficient data not only to prove these assumptions one way or the other, but also to discover the best trees from which to take seed for future planting.

In that year—remarkable for the initiation of similar but completely independent work in Trinidad and in Nigeria—Mylord chose his selection block on which to carry out observations. This block consisted of 5,440 trees planted in 1907 and in 1908 at a uniform spacing of 4 x 4 meters which is equivalent to 254 trees per acre. I was informed that the trees were then markedly similar in size; when visited in 1940 the tree population of the block was still very uniform. The trees belong to the Trinitario Complex. Each of the 5,440 trees was tagged, and individual

Table I.

Selected Trees.

Tree Number.	Colour of Pod.	Yield in Pounds Wet Cacao.		Total.	Total Yield in Pounds Dry Cacao.*	Total Number of Pods.		Pods to the Pound of Dry Cacao.
		1930.	**1931.**			*Good.*	*Black.*	
1204 ...	Green	36.9	39.3	76.2	30.48	367	79	12.0
1849 ...	do.	35.1	35.6	70.7	28.28	292	154	10.3
5303 ...	do.	35.9	32.8	68.7	27.48	235	110	8.6
3959 ...	do.	35.7	32.3	68.0	27.20	376	66	13.8
4357 ...	do.	28.3	38.5	66.8	26.72	298	153	11.1
1214 ...	do.	36.8	27.0	63.9	25.52	285	125	11.1
329 ...	do.	39.5	23.4	62.9	25.16	215	99	8.5
2517 ...	do.	20.9	41.9	62.8	25.12	283	130	11.2
3803 ...	Red	38.5	23.6	62.1	24.84	316	44	12.7
1262 ...	do.	29.4	31.9	61.3	24.52	256	95	10.4
4266 ...	do.	28.6	32.1	60.7	24.28	304	86	12.5
5064 ...	Green	32.1	27.8	59.9	23.96	274	133	11.4
5386 ...	do.	31.8	27.7	59.5	23.80	312	65	13.1
181 ...	do.	28.6	30.4	59.0	23.60	259	36	10.9
1481 ...	do.	29.3	29.4	58.7	23.48	231	148	9.8
4005 ...	do.	30.0	28.3	58.3	23.32	306	92	13.1
109 ...	Red	27.1	30.5	57.6	23.04	261	54	11.3
3962 ...	Green	29.8	27.6	57.4	22.96	208	140	9.0
2571 ...	do.	26.0	31.2	57.2	22.88	303	101	13.2
896 ...	Red	28.3	28.3	56.6	22.64	234	26	10.3
4608 ...	Green	28.0	28.5	56.5	22.60	278	80	12.3
3759 ...	do.	28.5	27.3	55.8	22.32	308	42	13.7
121 ...	do.	29.3	26.4	55.7	22.28	203	96	9.1
5014 ...	do.	25.4	30.0	55.4	22.16	348	73	15.7
5068 ...	do.	28.9	25.9	54.8	21.92	278	75	12.6
2071 ...	do.	12.5	41.9	54.4	21.76	248	63	11.3
4271 ...	Red	29.3	24.6	53.9	21.56	279	175	12.9
4564 ...	Green	31.3	22.4	53.7	21.48	187	82	8.7
5353 ...	do.	27.2	26.1	53.3	21.32	265	73	12 4

* Calculated on the assumption that Dry Weight = $\frac{4}{10}$ × Fresh Weight.

FIGURE 1.

YIELD OF GREEN AND RED POD CACAO.

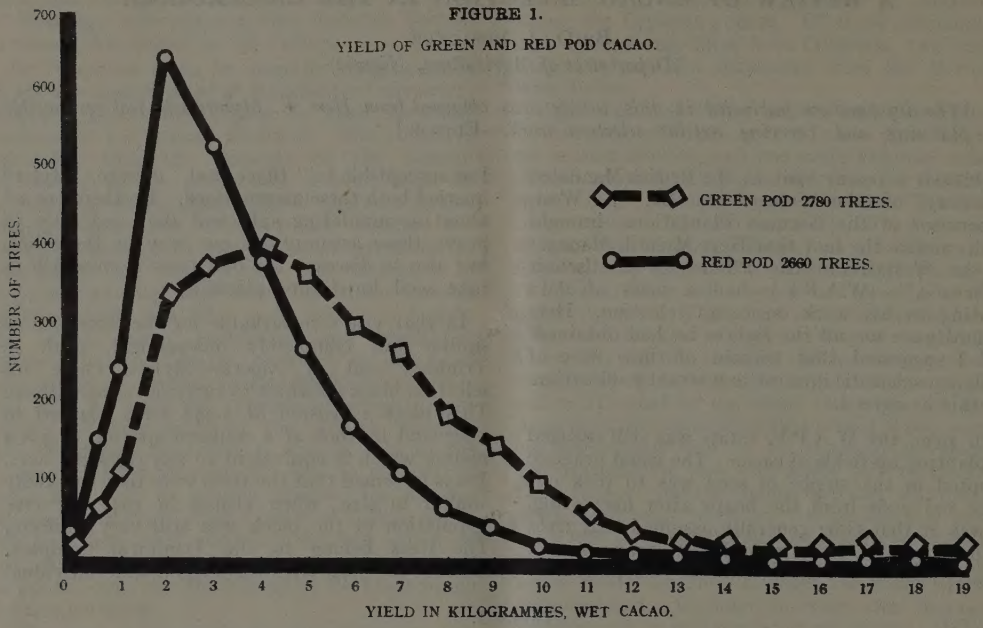
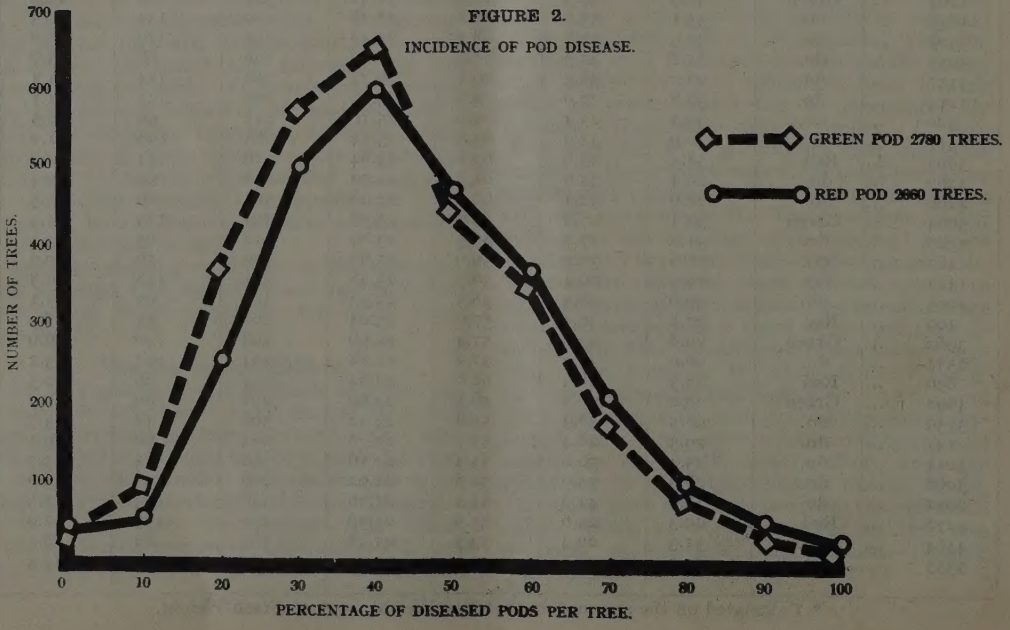


FIGURE 2.

INCIDENCE OF POD DISEASE.



yield recording was begun in June 1930. Trees were harvested at weekly intervals during the main season, but only when necessary between seasons. The following records were kept:—

Number of good pods.
Weight of wet beans from good pods after the removal of the placenta.
Number of large black pods.
Number of small black pods.
Colour of the pods.

Large black pods yield a saleable cacao of low grade; beans from small black pods—those attacked by Phytophthora before maturity—are valueless. No account was taken of wilted cherelles. Examination of the pod colour showed that there were 2,780 trees with green pods and 2,660 trees with red.

Yields.

The yields per tree for one year have been plotted in Fig. 1 from a summarized table of figures prepared by Mylord. His object was to find out whether the green pod types yielded as well as, or better than, the red pod trees. Fig. 1 shows that there is a strong indication that the green pod trees give a higher yield of wet cacao than the red, although individuals of the latter class are among the heaviest yielders. It would of course be unsafe to assume that a similar superiority of green pod cacao would be found in other blocks of Trinitario hybrids. But Mylord has certainly shown that there is nothing to be gained in yield by choosing large red pods at random for planting purposes.

A superficial examination of the ratio of "number of pods" to "weight of wet beans" confirms Pound's (1) analysis of the Trinitario complex in Trinidad. As would be expected, the range of variation in this ratio does not appear so great in the W.A.P.V. selection block as in the cacao tree population—smaller in numbers but more diverse in origin and locality—on which Pound based his conclusions.

Black Pod Disease.

The second assumption Mylord queried was that the red pods were less susceptible to disease. Fig. 2 shows the percentage of diseased pods from the red and green pod trees. It appears that pod colour has not the slightest influence on susceptibility to pod disease.

Selected Trees.

As a result of two years' yield recording 29 trees were selected. Data concerning these are presented in Table I. It will be noticed that the best of these selected trees is yielding at the rate of 33 cwt. per acre, the worst at 23 cwt. per acre. As the average yield on estates in the Cameroons is only approximately 2 cwt. per acre, there is ample scope for improvement. The similarity in yields of the selected trees and of the general average between Trinidad and the Cameroons is striking, but Black Pod disease is far more severe in the Cameroons, and in fact accounts for approximately 50 *per cent.* of the crop.

It is perhaps a little pathetic to record that in 1933 the W.A.P.V. estate was forced to give up cacao planting; no use was made of the selected trees owing to a lack of land suitable for cacao, and since then all the tree labels have been lost. This brief review is all that remains of two years' continuous and conscientious work undertaken by Mylord and his European assistant.

Acknowledgments.

Herr Mylord has asked me to acknowledge the work that the Westafrikanische Pflanzungs-Gesellschaft "Victoria" has done in carrying out this cacao selection. I wish, for my part to thank Herr Mylord for giving me all the data and for translations of notes connected therewith.

I am deeply indebted to Mr. J. West, Supervisor of Plantations, for having brought the facts to my notice, and to Mr. F. E. Stafford, Custodian of Enemy Property, and to Capt. J. R. Mackie, Director of Agriculture, for permission to publish.

Reference.

(1) Pound, F. J.—The Genetic Constitution of the Cacao Crop. *First and Second Annual Report on Cacao Research*, Imperial College of Tropical Agriculture, 1932, 1933.

A NEW METHOD IN MANGO PROPAGATION.

This method is simply a greenwood side graft in which the wood of the stock for preference and of the scion always is immature. The scion wood is unpetioled, the leaves having been cut off some days before. The stock is young seedling material. Older stocks (10-15 cm. diameter) and trees can be topworked by this method by grafting on the vigorous shoots that arise after stock or tree has been headed back. The stock is cut 5-10 cm. from the ground, leaving two or three leaves in place. The tie is made with cotton string tape of the kind used in shops and composed of several thread lines pasted flat in one narrow strip. It must be wound close and tight to exclude air and is kept in place until the scion stem begins to swell. Ordinary waxed budding tape is not satisfactory as it has not sufficient give. No graft cover is needed even in strong sunlight. The success of the graft before growth starts can be gauged with the aid of an electric torch at night; if alive and working the scion looks lustrous and turgid. Internal activity can also be detected by the presence of ants on the scion in search of sugar secretion. The top of the stock is removed when the scion reaches a length of 30 cm. but any new shoots which start on the stock must be eliminated as soon as they occur. The best time for grafting is between flushes. Many other directions not differing from common practice are given.—(*Horticultural Abstracts*, Vol. IX, No. 4, p. 372.)

PROGRESS OF SUGAR-CANE AGRICULTURE IN ST. KITTS DURING THE PERIOD 1933-40.

By P. E. Turner.
Adviser in Sugar-Cane Experiments to the Commissioner of Agriculture.

Introduction.

In 1933 a scheme of field experiments was inaugurated in St. Kitts under the auspices of a Sugar-Cane Investigation Committee. As in Antigua (1) the main aim of the scheme is to make thorough and systematic enquiry into the fundamental practices of agriculture in standard use in the sugar areas of the island. In this paper there are briefly outlined the main achievements of the scheme during the seven years which it has been in operation. The trend of development of the schemes in Antigua and St. Kitts, and the nature of the findings in the two islands, afford an interesting comparison.

The agricultural practices in use in St. Kitts in 1933 have been reviewed elsewhere (2, 3). The results of the earlier experiments have been recorded in *Tropical Agriculture* (3) and of the later experiments in various publications by the author and others (4). Abstracts from these publications are to be found in the *Annual Reports on the Agricultural Department of St. Kitts-Nevis* (5).

In 1931 H. E. Box (6) began his researches on the control of moth borer in St. Kitts. Tractors for furrowing and for transporting cane to the railway sidings have since been imported. The investigations of Box and his collaborators and the introduction of mechanical methods of cultivation and of haulage have greatly assisted in the progress made by the industry. Reference will later be made to new varieties of cane obtained from Barbados.

The island of St. Kitts is mountainous. There is a gently sloping glacis of detrital volcanic material from 1,100 feet to sea level. Sugar cane is grown on this glacis. The soils are light, sandy loams except in the north-west of the island where fine silt predominates over sand. They are low in organic matter.

The sugar areas of St. Kitts can be grouped into lower lands, upper lands and middle lands. The lower lands, which form the coastal belt at the foot of the glacis, in general are fertile and deep. The upper lands, which lie on the higher slopes of the glacis, are variable in depth, have suffered severely from erosion, and are less fertile. The middle lands possess intermediate characteristics.

Zones of low rainfall, in which lack of moisture is an important factor limiting crop yield, and of good rainfall obtain on the lower lands. Rainfall as a rule is abundant and well distributed on the upper lands. It is ample except in special areas on the middle lands.

Cultural Methods.

The soils of the lower lands, and of the middle lands in general, are open and porous. On the upper lands, and in some areas of the middle lands, the soils tend to become compact. The soils of all areas are easy to work and can be tilled shortly after heavy rain without harm.

No system of field drains is needed in any part of the island.

Ploughing.

The effects of ploughing (as distinct from furrowing) to depths of 6 and 12 inches on yield of cane have been measured on deep soils but this operation was not found to give rise to immediate or residual gain in yield of cane. On deep soils there are indications that ploughing may have an adverse effect on yield in very dry years.

The shallow soils of the upper lands could be deepened by ploughing but this would increase the danger of serious damage from erosion during heavy rains. Ploughing of these soils is therefore not to be recommended. There is little doubt, however, that root penetration is restricted in the shallow soils and that yield of cane is thereby limited.

Furrowing (or Banking).

Furrowing (or banking) is the only tillage operation which is practised preparatory to planting. In 1933 it was performed by cattle-drawn implements in the more accessible areas and by hand in the less accessible areas. It is now to some extent carried out mechanically. The new furrows are made between the lines of stools left from the previous crop.

On the upper lands and on the steeper middle lands the unworked strips of compacted soil between the furrows act as buffers which tend to prevent sheet erosion during heavy rains before the crop is established.

Contour furrowing.

In 1933 no particular attention was paid to the direction of the furrows on the hillsides. Contour furrowing has now been largely and successfully adopted.

Cross barring the furrows.

It was the general practice to make bars of earth (cross bars) across the furrows at intervals equal to the planting distance. Cane is planted in the cross holes thus formed. The cross bars prevent rush of water down the furrows if the rainfall is not sufficiently heavy to cause

them to collapse. Cross barring has been found unnecessary even on the steeper hillsides, provided that contour furrowing has been adopted, and is now less generally practised.

Tillage of furrow bottoms.

Chiselling (knifing) the compacted and partially weathered subsoil of the furrow bottoms has been tried in order to deepen shallow soil of the upper and middle lands. The operation was carried out with cattle in the wet season and no gain in yield was obtained. Chiselling by mechanical means under dry conditions would probably have given more satisfactory results for the success of chiselling depends on shattering rather than cutting through the subsoil.

Deep furrowing is recommended in shallow soils until mechanical tillage of the furrow bottoms in the dry season is possible. The operation should be performed early in order that the deep furrows may become in part filled with weathered soil before planting.

Tillage after Planting.

It is customary to till the unworked soil between the furrows after planting.

In the deep soils this operation has been found unnecessary and is now carried out less frequently. In a very dry year it can have an adverse effect on yield probably because it exposes wet subsurface soil thereby facilitating loss of moisture.

Tillage of the unworked soil between the furrows is advisable in the compacted areas of the upper and middle lands. It can be done as soon as the young plants are established without greatly increasing the danger of erosion.

Complete breaking of the banks between the furrows in order to give a flat surface to the soil is not essential for maximum yield but it enables the cane more easily to be cut flush with the soil and it facilitates carting during the crop season.

Tillage of Ratoons.

As difficulty is experienced in St. Kitts in getting the cane cut flush with the soil, the ratoon stools are moulded with earth. It has been shown in a dry area that this operation can lead to loss in yield in a dry year. On no occasion has it been found to give rise to gain in yield.

In 1933 it was customary to range the trash on alternate rows between the ratoon stools and to till the strips of soil thus bared. On some areas the trash was then transferred to the worked rows to enable the uncultivated strips to be tilled. In no circumstances has tillage of ratoons so far been found to give rise to gain in yield provided that the soil has been satisfactorily worked when under plant cane. To prevent smothering of the ratoon stools it is advisable to remove the trash from their immediate vicinity. Otherwise it is preferable to let it remain undisturbed as a mulch for minimising loss of soil moisture during dry periods. Tillage of ratoons has decreased during recent years.

Weeding of Plants and Ratoons.

Clean weeding is essential for the conservation of soil moisture under the conditions which obtain in St. Kitts and has been rigorously practised for many years.

Mulching in the Dry Areas.

Mulching of plant cane is not undertaken as a routine operation in the dry areas. Megasse as well as trash is available for the purpose and both have been found in dry years to give rise to large gain in yield of plant cane and on occasion to residual gain also.

In view of the rapidity with which the soils of the dry areas lose moisture during drought it has been found essential for the mulch to be applied to young plant cane before the end of the wet season if maximum gain is to result. In the case of megasse a mulch two to three inches deep has been found most satisfactory as the moisture from light rains is absorbed by a thicker blanket before it penetrates to the soil. With trash, a mulch five or six inches is necessary for maximum benefit. Larger gains in yield have been obtained by completely covering the soil with the mulching material than by spreading it on alternate rows between the stools.

Megasse is supplied to the railway sidings of the estates in the form of compressed bales. Breaking up the bales and distributing the megasse over the soil by hand is a costly operation. If inexpensive mechanical means were available of disintegrating the bales and spreading the material it is likely that mulching with megasse would be largely practised on the drier lower lands. Problems as to the most efficient method of collecting trash from the field for stacking and later use as a mulch await solution also.

On the drier lower lands a complete inorganic manure with a mulch of megasse has been found in a dry year to give considerably larger yield of plant cane than pen manure supplemented with inorganic nitrogen.

Mulching is not likely in general to give paying gains in yield in the wet areas.

Varieties.

A large number of varieties, mainly from Barbados, have received exhaustive and critical trial in the wet, intermediate and dry zones of the lower, middle and upper lands. In consequence the varietal situation in the island has undergone much change.

In 1933 the two standard varieties were S.C. 12/4 and B.H. 10 (12). The former was commonly grown on the drier lower lands, and the latter on the wetter lower lands, the middle lands and the upper lands. S.C. 12/4 has now been completely replaced by the new variety B.2935 on the drier lower lands. B.2935 has also largely replaced B.H. 10 (12) on the drier middle and drier upper lands and on the wetter lower lands. Further B. 2935 has spread to the wetter middle lands and to a seriously eroded area of the wet upper lands.

TABLE I.

*Increase in total area under B.*2935 (1937-40).

Crop year.	1937.	1938.	1939.	1940.
Percentage of total area harvested ...	3.3	16.1	31.5	47.8

Data recording the extension of the area under B. 2935 harvested during the period 1937-40 are set out in Table I. The earlier increases were mainly at the expense of S.C. 12/4 and the later at the expense of B.H. 10 (12).

B. 3439, another new variety, has been shown superior to B. 2935 for late reaping on the drier lower lands and is likely to become a standard cane. B. 3439 is also showing promise in experiments on the wet lower lands and on the drier middle and upper lands.

Time of Planting.

WET-SEASON PLANTING.

In order to obtain maximum yield of cane it has been shown that planting operations should commence late in August or early in September on the upper lands and should progress downwards towards the coastal belt. The wetter lower lands should be planted by the end of October, for later planting leads among other things to slow early growth of the young cane. The drier lower lands should be planted between the middle of October and of December (November being in general the optimum month), for with earlier planting there is considerable chance of the young cane being too advanced in growth to withstand a long dry season, and later planting involves the risk of the advent of the dry season before the early manures can be absorbed by the young cane.

Time of planting in the wet season was in the past to some extent dependent on the supply of pen manure, the operation being delayed until this manure became available in sufficient quantity. It has been shown that such delay is unnecessary if suitable use is made of inorganic manures.

The findings of the experimental scheme with regard to time of planting in the wet season are in practice in general.

DRY-SEASON PLANTING ('FORCING BACK')

Planting in the dry season within a few weeks of reaping the previous crop ('forcing back') can be successfully practised on areas in which the young cane makes rapid early growth, and is recommended in moderation in these areas. With 'forcing back' a crop of plant cane is reaped in one year instead of two years. Further the soil remains uncropped and bare for a few weeks instead of many months and loss of organic matter through exposure to the sun is reduced to a minimum. No fear need be entertained that 'forcing back' leads to soil exhaustion provided that manurial treatment is satisfactory.

There has been some extension of dry-season planting in recent years.

Germination.

On certain of the wetter middle and upper lands germination (as distinct from slow early growth) of cane planted after the end of October is poor. It is probable that in these areas the material available for planting has by this time become too mature for the purpose. The practice of cross barring, which collects water in the furrows on compacted soils, also tends adversely to affect germination. The difficulty can be largely overcome by planting at the optimum time and by contour furrowing without cross barring. Methods of improving germination are under study to meet conditions under which planting at the appropriate time is not possible.

On the lower lands excellent germination is obtainable if moisture conditions are suitable. Late planting entails the possibility of poor germination in circumstances such that months may elapse before there is adequate rain for satisfactory supplying.

Spacing of Plants.

Optimum spacing of plants has been shown to be closely dependent on rainfall provided that choice of variety, time of planting and manurial treatment are suitable. It has been found that in the drier areas the most satisfactory distance of spacing on the average is $4\frac{1}{2}$ feet by 4 feet, whereas in the wetter areas the distance should not exceed $4\frac{1}{2}$ feet by 3 feet. These findings are largely in use.

Modifications in the distance of spacing have been shown to affect the yield of plant cane to a greater extent than that of ratoons in both wet and dry areas.

Manures.

LIME.

In general the lower lands are neutral in reaction whereas the middle and upper lands are acidic. Liming has been sporadically practised for many years, a slaked lime obtainable from local sources being used.

On the acid soils it has been established that liming gives rise to paying immediate and residual gains in yield, that the optimum economic dressing lies in the region of half the lime requirement of the soil, and that a dressing in excess of the lime requirement is definitely inadvisable.

A field-to-field survey of lime requirement is now in operation. Twelve samples are taken to the acre and the lime requirement of the bulked samples for each field, or portion of each field, are measured. The method of measurement is quantitative (7) and is based on the well-defined relationship found to obtain in the field experiments between degree of unsaturation of the soil with exchangeable calcium and response in yield of cane to size of dressing of limestone. A similar quantitative relationship had earlier been established in Trinidad.

TABLE II.

Imports of crushed limestone into St. Kitts, 1935-39.

Year.	1935.	1936.	1937.	1938.	1939.
Imports of crushed limestone (tons)	Nil	258	222	420	670

A crushed limestone of high quality and of fine division (70 per cent. or more passing through a 100 mesh B.S. sieve) is becoming increasingly popular in St. Kitts. The quantities of this material imported in recent years are recorded in Table II. Much larger amounts are likely to be used as the survey progresses and the optimum quota of lime for each field becomes known.

ORGANIC MANURES.

Pen manure and fish manure.

The lower lands and the more accessible middle lands are commonly penmanured at the rate of 20 tons to 30 tons to the acre at each replanting. When the supply of pen manure is inadequate fish manure at the rate of 4 cwts. to 6 cwts. has been used in some areas. The upper and less accessible middle lands are rarely dressed with organic manure because of the difficulty and cost of cartage.

Unrotted pen manure, and even megasse, decompose quickly in the soils of St. Kitts, especially in the deeper soils of the lower lands. It is therefore not necessary to leave litter in the pens for a long period before removal to the field. Pen manure has been shown to give rise to larger gains in yield in wet than in dry years.

It has been found very costly to keep additional stock solely to augment the supply of pen manure. It is recommended that the amount available should continue to be distributed to the plant-cane areas in which conveyance is easy and inexpensive and that it should be evenly applied over these areas.

There is good reason to believe that organic manures such as pen manure and fish manure are not essential for the satisfactory growth of sugar cane even in the dry areas. For example, in a dry area it has been established that a complete inorganic manure with a mulch of megasse can give rise in a dry year to considerably larger yields of cane than a dressing to the acre of 30 tons of pen manure supplemented with inorganic nitrogen. Critical experiments have not been laid down in the wet areas but evidence is available which indicates that there is little to choose between the yields obtained from pen manure with inorganic manure and from complete inorganic manure alone.

No benefit has been found to result from the use of fish manure rather than inorganic manure. The imports of fish manure in 1939 were much smaller than in previous years.

Molasses.

Dressings of molasses have been found to give rise to small and uneconomic gains in yield in a wetter area of the lower lands.

INORGANIC MANURES.

In 1932 an early dressing of sulphate of ammonia was not applied to plant cane on the lower, middle or upper lands. A late dressing of 2 cwts. to the acre was given to plant cane in both penmanured and unpenmanured areas after the end of the dry season, *i.e.* some six months or more after planting. Ratoon cane in almost all areas was given a late dressing to the acre of 2 cwts. to 3 cwts. sulphate of ammonia. Little faith was placed in the use of sulphate of ammonia except as a stimulant. No inorganic potash or phosphate was applied to plant cane or to ratoons.

During the period 1933-40 a large number of critical experiments have been laid down to determine the optimum size of dressings and times of application of inorganic manures to plant and ratoon cane. Special attention has been paid to the unpenmanured areas of the middle and upper lands.

Nitrogen.

Early as well as late dressings of sulphate of ammonia have in general been found necessary for plant cane in both the penmanured and unpenmanured areas. The optimum economic treatments to the acre for the lower, middle and upper lands are summarised below. The early dressings should be applied four to six weeks after planting on the lower lands (where early growth is rapid), and six to eight weeks after planting on the middle and upper lands (where early growth is slower). The early dressing should in all cases be applied before the advent of the dry season which follows planting. The late dressing should be given before the advent of the following wet season to ensure maximum early use of the rains.

Drier lower lands :—
1 cwt. early and 3 cwts. late.

Drier middle and upper lands :—
2 cwts. early and 2 cwts. late.

Wetter lower, middle and upper lands :—
2 cwts. to 3 cwts. early and 2 cwts. to 3 cwts. late.

These recommendations for plant cane are naturally subject to variation to meet special conditions. For example, the early dressing of 1 cwt. should not be given to certain of the coarser and more porous soils of the very dry areas if pen manure has been applied.

The optimum dressing of sulphate of ammonia to ratoons has been shown to be 3 cwts. to the acre. The dressing should be applied to each ratoon crop in a single dose as soon as possible after reaping.

The amount of sulphate of ammonia used in St. Kitts is steadily increasing (Table IV). Data for earlier years than 1936 are not available but it is known that much less of this manure was used in 1932 than in 1936.

Experiments to compare the value of sulphate of ammonia with other inorganic nitrogenous manures are under way.

Potash.

It has been established that large areas of the island give paying response to potash. As in Trinidad (8) a well-defined relationship has been shown to exist in the field experiments between amount of exchangeable potash in the soil and response in yield of cane to size of dressing of potash. In St. Kitts, where very light soils predominate, the relationship has been found to depend on rainfall, *i.e.* the optimum economic dressing of potash for a soil with a given content of exchangeable potash is larger in a wet year than in a dry year. In Trinidad, where heavy soils predominate, the relationship does not appear to vary appreciably in wet and dry years.

Recommendations for manurial treatment of unpenmanured plant cane with potash, based on the data so far obtained from the field experiments in St. Kitts, are set out in Table III. They are to be regarded as provisional and are subject to amendment as further experimental information becomes available. The recommendations for a dry year correspond fairly closely with those which have been recorded for Trinidad (8). As no forecast of rainfall is possible the recommendations for a year of average rainfall are advised unless war conditions limit the supply of potash.

To ensure maximum beneficial effect the potash should be applied to plant cane with the early dressing of sulphate of ammonia. In the presence of pen manure the recommended dressing can safely be reduced by 1 cwt. to the acre.

TABLE III.

Provisional recommendations for manurial treatment of plant cane with potash on unpenmanured soil in St. Kitts.

Muriate of potash per acre.	Exchangeable potash in soil.	
	Year of average rainfall.	Year of low rainfall.
Nil ...	Over 130 p.p.m.	Over 100 p.p.m.
1 cwt. ...	130-100 p.p.m.	100-80 p.p.m.
1½ cwts. ...	100-70 p.p.m.	80-60 p.p.m.
2 cwts. or more ...	Under 70 p.p.m.	Under 60 p.p.m.

A dressing equal to two-thirds of that required by the plant cane is suggested for each ratoon crop on unpenmanured soil and for the later ratoons on penmanured soil. It should be applied as early as possible in the life of the ratoons.

In order to put the recommendations into full effect a field-to-field survey of potash requirement is under way. In this survey exchangeable potash is quantitatively determined in the soil samples collected for measurement of lime requirement.

The amounts of potash used in recent years in St. Kitts are recorded in Table IV. Data are not available for earlier years than 1935, but it is known that no potash was imported in 1932. Potash is used exclusively in the form of muriate.

TABLE IV.

Imports in tons of inorganic manures into St. Kitts.

Inorganic manure.	1932	1935	1936	1937	1938	1939
Sulphate of ammonia	*	*	1,120	1,276	1,509	1,583
Muriate of potash ...	Nil	235	273	481	487	444
Superphosphate of lime ...	Nil	66	203	250	182	201

* Data not available.

Phosphate.

It has been found in general that paying response in yield of plant cane can result from dressings of superphosphate in areas which have not been regularly penmanured in the past. The optimum economic dressing to plant cane has been shown to lie in the region of 1 cwt. to the acre and should be applied with the early nitrogen and potash. There are indications that larger dressings may have an adverse effect on yield. As in Trinidad no relationship has so far been found to obtain in the field experiments between amount of available phosphate in the soil and response in yield of plant cane to treatment with this manure.

There is evidence that ratoon cane does not require treatment with phosphate provided that the plant cane has received an adequate supply.

The amounts of superphosphate used in St. Kitts in recent years are recorded in Table IV. No superphosphate was imported before the inception of the experimental scheme.

Minor elements.

Small dressings of borax, zinc sulphate and magnesium sulphate have each been found to give rise to relatively large gain in yield of plant cane in a low-yielding area of dry upper land.

Early Benefits from the Experimental Scheme.

An account of some of the earlier benefits resulting from the experimental scheme is to be found in the *Reports on the Presidencies of the Leeward Islands Colony for the Year* 1937 (9).

Crop data for recent years and related statistics are recorded in Tables V and VI.

Between 1933 and 1937 the amount of inorganic manures imported into St. Kitts in the crop year increased from 703 tons to over 2,300 tons, *i.e.* by more than 200 per cent. whereas there was little change in the varietal situation (Table V). Progress in sugar cane production during these years is due in the main to this greater use of inorganic manures, aided by the findings of the experimental scheme in general, and by the work of Box (6) and his collaborators which reduced the joint infestation of sugar cane by moth borer from an average of 21 per cent. over the period 1932-33 to 7 per cent. over the period 1935-39.

In 1938 the proportion of the harvested area under the new variety B. 2935 became important (Table V) and the progress from then onwards is attributable to varietal causes also.

TABLE V.

Increase in harvested area under sugar-cane in St. Kitts (1933-39) *and related statistics.*

Year.	Total area harvested (acres).	Proportion of area under B.2935 (per cent.)	Inorganic manures imported (tons).
1933 ...	7,715	—	703
1934 ...	7,630	—	1,102
1935 ...	8,105	—	1,345
1936 ...	8,508	—	2,334
1937 ...	9,029	3.3	2,342
1938 ...	9,760	16.1	2,181
1939 ...	9,665	31.5	2,228

The figures set out in Table V for imported inorganic manures (sulphate of ammonia, muriate of potash and superphosphate) from 1933 to 1937 are for the crop years (9). As the data for the crop years are not available for 1938 and 1939 the data for the calendar years are recorded.

INCREASE IN AREA UNDER SUGAR CANE.

One of the most important effects of the greater and more satisfactory use of inorganic manures has been to enable an increase in the harvested area from approximately 7,700 acres in 1933 and 1934 to approximately 9,700 acres in 1938 and 1939 (Table V), a gain of about 25 per cent.

On many areas of the less intrinsically fertile upper lands it did not pay to plant sugar cane in 1932. On some of the less shallow soils a crop of plant cane without ratoons could advantageously be taken off, but yields in general were not good and intervals of rest were needed between each planting during which the land was placed under pigeon peas. As a result of the manurial experiments periods of rest have been found unnecessary. A very large proportion of the upper lands is now continuously under sugar cane and, although the yields obtained are not as large as on the deeper lower lands, ratoon crops as well as plant-cane crops in general can be grown with profit.

Through greater use of inorganic manures longer ratooning has also been found to pay on many of the wetter lower lands and on the deeper and more fertile soils of the middle and upper lands which have been regularly in cultivation. This has helped to increase the proportion of the arable area under sugar cane at any one time.

INCREASE IN OUTPUT OF CANE AND SUGAR.

The data recorded in Table VI have been arranged in relation to rainfall. They cover the rainfall intervals 44 ins. to 49 ins., 55 ins. to 59 ins. and 63 ins. to 64 ins. The figures for 1933 have been omitted as the crop harvested in this year was seriously damaged by a gale.

When due allowance has been made for rainfall it will be seen that there has been a very large gain in the production of cane and sugar during the past decade. In the years of least rainfall there has been an increase in output of cane from somewhat less than 100,000 tons (1931) to rather more than 200,000 tons (1936 and 1938), and of sugar from about 12,000 tons (1931) to about 28,000 tons (1936 and 1938). In the years of intermediate rainfall there has been an increase from 164,000 tons (1932) to 205,000 tons (1935) and to 262,000 tons (1939) in the case of cane, and from 20,000 tons (1932) to 28,000 tons (1935) and to 36,000 tons (1939) in the case of sugar. In the years of greatest rainfall the

TABLE VI.

Increase in output of cane and sugar in St. Kitts (1931-39).

Year.	Rainfall (ins.)* for previous year.	Island output (tons).		Yield per acre (tons).		Tons cane needed for a ton of sugar.
		Cane.	Sugar.	Cane.	Sugar.	
1931 ...	45.98	98,209	12,021	16.11	1.97	8.18
1938 ...	44.78	200,210	27,935	20.51	2.82	7.27
1936 ...	48.89	201,633	28,174	23.70	3.29	7.20
1932 ...	57.60	164,259	19,969	25.13	3.05	8.24
1935 ...	55.34	205,192	28,491	25.25	3.52	7.17
1939 ...	58.38	262,501	36,363	27.16	3.76	7.22
1934 ...	63.97	200,211	28,320	26.23	3.62	7.25
1937 ...	63.12	256,551	34,260	28.41	3.77	7.54

* Yield is largely dependent on rainfall during the previous year.

output has increased from 200,000 tons (1934) to 256,000 tons (1937) of cane, and from 28,000 tons (1934) to 34,000 tons (1937) of sugar.

In spite of the extension in area under cultivation on the less fertile upper lands, and of longer ratooning, there has been an increase rather than a decrease in average yield to the acre for the island as a whole. In 1931, 1938 and 1936 the average yields of cane were 16.11 tons, 20.51 tons and 23.70 tons, and of sugar were 1.97 tons, 2.82 tons and 3.29 tons. In 1932, 1935 and 1939 the average yields of cane were 25.13 tons, 25.25 tons and 27.16 tons, and of sugar were 3.05 tons, 3.52 tons and 3.76 tons. In 1934 and 1937 the average yields of cane were 26.23 tons and 28.41 tons, and of sugar were 3.62 tons and 3.77 tons. It would appear that there has been an increase in average yield on the more fertile areas which has more than counterbalanced the smaller yield obtainable on the less fertile areas recently taken into regular cultivation.

It is of interest that there has been an appreciable reduction in the amount of cane needed to make a ton of sugar during the years of least rainfall and of intermediate rainfall during the past decade.

Reduction in Cost of a Ton of Cane.

Costings data are not available but there can be little doubt that the findings of the experimental scheme have led to a reduction in unit expenditure. The increase in area under regular cultivation and longer ratooning has lowered the overhead charge for a ton of cane. Longer ratooning has enabled a larger number of crops to be reaped between the comparatively costly operations involved in replanting. Further, the confidence now placed in inorganic manures has led to a reduction in the expenditure on stock, a costly item in the working of the estates.

Schedule of Agricultural Operations.

By contrast with Antigua (1), the porous nature of the soil and the existence of zones of high, intermediate and low rainfall in St. Kitts enable much greater latitude in the times at which the various items in the sequence of agricultural operations can be carried out with optimum efficiency. Nevertheless maximum results cannot be obtained in St. Kitts unless the findings of the experimental scheme with regard to cultural methods, mulching, varieties, time of planting, spacing of plants and manurial treatment are put fully into operation, and unless good use is made of fresh information as it becomes available.

Acknowledgments.

The idea of the investigational scheme on sugar cane in St. Kitts, as in Antigua, was conceived by the late Mr. G. Moody Stuart, C.B.E. The scheme was launched by Mr. G. A. Jones, C.M.G., then Commissioner of Agriculture.

The scheme is financed equally by the cane growers and by the St. Kitts (Basse Terre) Sugar Factory. The original contribution by each party was one cent for each ton of cane delivered to the factory. The contribution has recently been increased by one-half.

The author wishes to place on record his indebtedness to the sugar estates for their very helpful co-operation in this work and to Messrs. R. E. Kelsick, E. R. H. Martin, G. B. Gregory and J. M. Cave for the valuable assistance which they have given.

The soil survey with respect to lime and potash is in the hands of Mr. E. A. Evans.

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LAND PRODUCTIVITY MAP OF TRINIDAD, B.W.I.

Copies (price: 1*s.* per copy, post free) of The Tentative Land Productivity Map of Trinidad referred to in Professor Hardy's article on "A Provisional Classification of the Soils of Trinidad" which appeared in the 1940 August issue of this Journal may be obtained on application to the Editor, *Tropical Agriculture*, Imperial College of Tropical Agriculture, St. Augustine, Trinidad, B.W.I. Separate copies of the Table at 3*d.* each can also be supplied.

SOME NOTES ON P.O.J. 2878 IN BRITISH GUIANA.

By L. S. Birkett, A.I.C.T.A.

Prior to 1934, the standard variety of cane grown in British Guiana was D 625, a variety bred in 1892 and one that retained its leading position in this Colony for over a quarter of a century. With the reorganisation of the Department of Agriculture of British Guiana in 1928, there was an extension of its research work, with varietal studies forming one of the major lines of investigation. Experiments soon demonstrated the superiority of the varieties Diamond 10 and P.O.J. 2878 over D 625, and the planting community was not slow in substituting these varieties for D 625. The rapidity of this change is shewn in Table I which gives the percentages of the three major varieties under cultivation since 1934 (1).

It will be observed that P.O.J. 2878 has been extended very rapidly, while the 1940 plantings suggest that it has started to displace Diamond 10, and will be the paramount variety in the near future.

P.O.J. 2878 in the Field.

P.O.J. 2878 has proved itself an excellent field cane in British Guiana. Yields of sugar per acre are somewhat higher than those obtained from Diamond 10, and it is more tolerant to extremes of flooding and drought than are the other varieties. Among its outstanding advantages are its rapid germination and ability, (by its rapid growth), to cover ground quickly and thereby reduce the cost of weeding.

P.O.J. 2878 in the Factory.

Until the Autumn Crop of 1939, and the Spring Crop of this year, the juices of this variety in British Guiana have not, except in one or two isolated cases, given the trouble to clarify which has usually been experienced with this variety when cultivated outside Java, its country of origin.

The conditions under which clarification difficulties have arisen in British Guiana are worthy of note, being dissimilar to those so far recorded in the numerous references in the literature to this variety. Many reasons have been advanced for the difficulties experienced in clarifying the juices of P.O.J. 2878, and several clarification methods have been tried with the object of overcoming them. The following brief review of the literature summarises the various views expressed in this connection.

Forero (2), in Cuba, ascribes clarification difficulties to immature cane, and suggests that a wider planting be adopted to aid maturity. He also suggests that the cane be left about ten days in the field prior to transporting to the mill. This writer is of the opinion that during this interval, internal changes occur that amount to an acceleration of maturity or ripening. In Hawaii, McCleery (3) records the slowness with which the juices of P.O.J. 2878 settle when simple lime defecation is practised. Similar observations are made by Hadfield (4) and Fleshman (5).

The P_2O_5 contents of the juices of P.O.J. 2878 in Hawaii are variable but generally high (6). Where there is a deficiency of P_2O_5 in the juice and the difficulties are moderate, additions of phosphates result in improvement of clarification (5). Mono-ammonium phosphate "A", and superphosphates are used, but the former appears to be preferred (7). McCleery advocates liming the juice to pH 11.0 and then bringing back to a suitable pH of clarified juice by additions of double or treble super-phosphate in the cold after liming. With very refractory juices, clarification difficulties are largely overcome by juice sulphitation (7), (8).

In Brazil, de Carli (9) makes substantially the same observations as McCleery, while Caminha (10), attributes the difficulties encountered to the low P_2O_5 content of the juices and the peculiar nature of the colloids present in the juices of this variety. In Puerto Rico, Davis (11) also records difficulties in defecation at times. Stress is laid on the importance of proper cultivation practice, well drained soils, proper fertilizer practice and a plentiful water supply by irrigation or rain.

Salinas (12), claims that the difficulties are due to the cutting of immature cane and especially to the presence of a large proportion of secondary shoots deficient in P_2O_5 and coagulable albuminoids. In the Philippines, Gordon (13) also considers that clarification difficulties are probably due to the presence of a large percentage of immature shoots at reaping. The same reason is given by Baissac (14) for clarification difficulties in Mauritius, the greatest trouble being experienced during the "petite saison" during which the cane is generally more immature than during the "grande saison".

In Jamaica the P_2O_5 content of the juices of P.O.J. 2878 is low (15), and Springer (16) reports that additions of P_2O_5 improve clarification even

Table I.

	1934.	1935.	1936.	1937.	1938.	1939.	1940.
P.O.J.2878	1.4	4.7	9.7	19.2	31.7	45.7	57.6
Diamond 10	16.8	22.7	29.4	36.6	41.3	43.5	37.1
D.625	62.5	55.4	44.6	33.0	20.6	8.0	2.8

when the addition is as low as 0.005 per cent. P_2O_5 on juice. On the other hand, Davies (17), (18) reports that in Trinidad the P_2O_5 content of the juices of P.O.J. 2878 is high, being more than double that of B.H 10(12) the juices of which clarify very easily. He also records that the juices and syrups of this variety froth abnormally, and the writer has observed this phenomenon in Trinidad, even when this variety was ground along with B.H. 10(12). Poey (19) in Cuba, and Guillaume (20) in Martinique, also note this property of P.O.J. 2878 juices.

Summarising the foregoing, the two chief reasons given for the clarification difficulties experienced with juices of P.O.J. 2878, are: a deficiency of P_2O_5 in the juices, and the presence of immature shoots or tillers.

Behaviour of P.O.J. 2878 in British Guiana.

The conditions under which clarification troubles were first widely experienced in British Guiana, are in direct contrast to this view, for during the 1940 drought the P_2O_5 content of the juices was higher than usual in this Colony, and the cane was singularly free from secondary shoots and tops. In fact, the cane ground was more mature (being of a higher sucrose content and lower in reducing sugars) than has ever been obtained since the introduction of chemical control in British Guiana.

An increase in the P_2O_5 content of the juices is to be expected during severe dry weather, due to concentration of the juices. However, there was an actual increase of P_2O_5 on a non-sucrose basis as a result of the drought, as is illustrated by the figures in Table II, pertaining to the 1939 Autumn and the 1940 Spring crops at Blairmont.

Table II.

Average Phosphate Content.

Crop.	Grs. per 100 ml. Crusher Juice.	% Non-Sucrose.
1939, Autumn ...	0.0168	0.530
1940, Spring ...	0.0216	0.684

In British Guiana, the P_2O_5 content of the juices of all cane varieties is generally low, the usual range being from 0.012 to 0.022 grs. of P_2O_5 per 100 ml. (Crusher Juice). Additions of P_2O_5 to juices almost invariably produce an improvement in clarification, but such additions are accompanied by considerable increases in the volume of muds to be handled at the presses, and with the press capacity available at the factories this practice can only be maintained for short periods.

One of the outstanding features of cane cultivation in British Guiana is the fact that climatic conditions and cultural practice militate against ripening, and the cane is seldom fully mature when reaped. The sucrose content is relatively low and the reducing sugars ratio high. It appears that in British Guiana, clarification troubles are to be expected with P.O.J. 2878 when this variety attains maturity (as measured by the reducing sugars pol. ratio), and that these troubles have been avoided in the past by reaping slightly immature cane. It should here be remarked that in Java where this variety causes no outstanding clarification difficulties, close planting and irrigation is usual; practices which tend to prolong growth and hence reduce ripening. The comments by Davis (11) as to the necessity of a plentiful water supply and adequate fertilizer additions to this variety for avoiding clarification troubles, further support this view.

In addition, the procedure of leaving cut cane for ten days in the field prior to milling, as advocated by Forero (2), is more likely to result in enzymic changes which correspond to renewed growth rather than to ripening. In contrast to Forero's recommendation, Davies (21) has shewn that in Trinidad it is unwise to allow P.O.J. 2878 to become stale, as this increases clarification and other difficulties in the factory. This is also the case in British Guiana. Davies attributed these difficulties to an increase in furfural-yielding substances in the juices from stale canes. The presence of these compounds in the juices could perhaps be due to the production of soluble pectins from cell-wall pectin as a result of enzymic action (pectase).

The conditions in British Guiana under which clarification troubles with the juices of P.O.J. 2878 have arisen, demonstrate that the real cause of the trouble is not entirely a deficiency of P_2O_5 or immature cane or tillers, although these must contribute to poor clarification as they do in the case of other varieties. The real causes of the difficulties are at present unknown.

The most recent research on the clarification of cane juices (18) shews that there is a correlation between the percentage of silica in organic form and the clarifying properties of the juices. A high percentage of organo-silicates is correlated with poor clarification and *vice versa*.

In view of the importance of P.O.J. 2878 in so many cane-growing countries, it is desirable that further research into the fundamental reasons for these clarification difficulties should be conducted.

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USE OF THE SPECTOGRAPH IN AGRICULTURAL CHEMISTRY OF SUGAR CANE.

By S. S. Ballard.*

The spectograph has been perfected to a point where it can be used for quantitative analysis, especially for estimation of elements in concentrations of 0.7 per cent. or below. A spectographic analysis of the ash of the cane, variety H.109, grown at Makiki, showed the following elements in the order of their quantitative importance :—

Major.	*Minor.*	*Trace.*
Potassium	Manganese	Boron
Phosphorus	Strontium	Barium
Silicon	Magnesium	Copper
Calcium	Iron	Sodium

This is a complete spectographic analysis of this sample, and accounts for all the metals present. Zinc, if present in trace quantity, must be less abundant than 0.01 per cent., aluminium less than 0.001 per cent., &c., where the amounts quoted refer to the ultimate sensitivity of detection of these elements.

Raw Sugar.—Composite samples of Hawaiian raw sugars of the 1938 crop gave the following approximate composition in per cent. of the ash :

Potassium	5.0
Silicon	1.0
Phosphorus	1.0
Iron	0.5
Calcium	0.1
Titanium	0.1
Aluminium	0.1
Manganese	0.1
Tin	0.05
Lead	0.01
Chromium	0.01
Magnesium	0.01
Sodium	0.01
Boron	0.01
Copper	0.005
Strontium	0.005
Barium	0.005
Nickel	0.001

It will be noted that the more plentiful elements listed are those found in sugar-cane in largest amounts : potassium, silicon, phosphorus and calcium, *plus* the most common soil metals, iron, aluminium and titanium. Some of the other elements found in the raw sugars may very well have been introduced in the milling process. This list includes additional iron and calcium, and tin, lead, copper, and nickel.

Cane-juice.—A spectographic analysis was made of locally-consumed sugar-cane juice concentrate. The syrup was ashed and the ash showed the following elements present :—

Major.	*Minor.*	*Trace.*	*Small Trace.*
Phosphorus	Calcium	Copper	Titanium
Silicon	Magnesium	Strontium	Barium
Potassium	Manganese	Tin	Vanadium
	Iron	Boron	Nickel
		Sodium	Chromium
		Aluminium	

Sugar-Cane.—Attempts have been made to apply the spectograph to a study of sugar-cane where growth failure has been noted, in the expectation that a deficiency or excess of some minor element might be responsible. However, no definite differences which might denote a nutritional deficiency or toxicity were noted, except in the case of manganese, which appeared to be present in larger amounts in the cane leaves from the poor-growth area. The paper points out other directions in which spectographic analysis may be of interest in the examination of fertilizers, metals, and the like.—(*Facts about Sugar*, Vol. XXXV, No. 7, p. 35, 1940.)

* *Hawaiian Planters' Record*, Vol. XLIV, (1940) No. 1.

MEASURES FOR THE CONTROL OF CHINCH BUG INFESTING LAWNS IN TRINIDAD.

By Alan Pickles, M.Sc., A.I.C.T.A.
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The chinch bug (*Blissus insularis* Barber) is a well known pest of grasses of numerous species, including cereal crops. In the United States of America in particular, the literature dealing with the related *B. leucopterus* as a pest of cereal and fodder crops is voluminous but the activities of the chinch bug as a pest of ornamental lawns have received less attention until recent years.

In Trinidad, the chinch bug attracts attention only because of its activities in lawns and "savannahs" and there are few records of serious injury to crop plants.* The susceptibility to attack varies with the species of grass concerned; Savanna Grass (*Axonopus compressus*), which is in most general use as a lawn grass, is particularly subject to injury. It is only at intervals of about five years that the injury to lawns becomes generally serious and such years appear to be characterised by an abnormally low rainfall. This observation is in accordance with the known effects of rainfall on the multiplication of the insect and its fungus enemies in the United States (4).

The year 1940 has been remarkable for exceedingly severe and widespread outbreaks of long duration. Efforts have therefore been made to determine a method of control which could be adopted by householders.

As a pest of field crops, the chinch bug may be controlled by mechanical barriers around the fields and by destruction of wild host plants. These methods are inapplicable to infestations of lawns and the use of insecticides alone can cope with the problem. Insecticides, indeed, are often employed as an additional method of control when field crops are infested (2), but in the case of a lawn, where the infested plants are closely interlaced and whose leaves and roots form a dense mat over and within the soil, efficient spray application is much more difficult than in the case of relatively widely-spaced crop plants. The problem of control is also complicated by the difficulty of detecting an infestation on a lawn before serious damage has already taken place.

Description of the Damage.

Infested grass quickly turns yellowish in colour and later becomes brown and dead. The infestation on the lawn is first noticed as a rule when numerous irregular patches of dead and discoloured grass are present. The common weeds of lawns are not attacked by the chinch bug and the dead patches consequently rapidly become invaded by weeds. Unless the infestation is controlled, the grass may be destroyed completely, only a dense mass of unsightly weeds being left.

* Since this account was written, a serious attack of chinch bug on rice has been observed in the south of Trinidad. The insects of all ages attack the maturing ears and do not affect the lower portions of the plant.

Experimental Results.

Many different substances were employed experimentally for the control of the pest including insecticidal dusts as well as fluid insecticides.

The only preparations which were found to be effective were (*a*) a solution of nicotine sulphate in soap solution, containing 1 part in 400 of 40 per cent. nicotine sulphate and (*b*) carbon bisulphide emulsion, containing one fluid ounce of carbon bisulphide per gallon. Both preparations are expensive, that containing nicotine sulphate especially so, particularly as both must be used in generous amounts to produce satisfactory results.

While the other materials employed gave unsatisfactory results it is probable that all killed a proportion of the insects, but not sufficient to justify their use as a practical control. The liquids tested for chinch bug control which were subsequently discarded included strong soap solution and emulsions of lubricating and fuel oils, applied at various rates up to 200 gallons per 1,000 square feet. A proprietary pyrethrum extract of unspecified pyrethrin content, diluted 1 : 300 with water, was ineffective when applied at the rate of 100 gallons per 1,000 square feet at a cost of $5.00 per 1,000 square feet, and its use in greater concentration was considered too expensive.

Nicotine dust (2 per cent. nicotine), derris dust (0.15 per cent. rotenone) and a proprietary preparation containing nicotine and rotenone in unstated amounts were applied, both separately and in admixture with sulphur, in amounts up to 25 lb. per 1,000 square feet and were brushed into the turf with a hard broom; all were ineffective.

Experiments were conducted with nicotine sulphate diluted with varying amounts of soap solution. The concentration of the soap solution employed was also varied and the liquid was applied in amounts up to 150 gallons per 1,000 square feet. The formula finally adopted was as follows:—

Common soap (blue or mottled soap)	2 lb.
Nicotine sulphate (40 per cent.)	½ lb.
Water	....25 galls.

The mixture was applied as a spray from a small power sprayer at a pressure of 200 lb. per square inch and, after treatment at the rate of 100 gallons per 1,000 square feet, the most meticulous search failed to disclose any living chinch bugs in the turf. Survivors were always found, however, if the concentration of nicotine or of soap was reduced or if a smaller amount of the spray was applied per unit area.

It has been stated (1) that nicotine sulphate applied to turf fails to kill the eggs of the chinch bug and that repeated treatment is necessary on that account. In the present series of investigations however, whenever an entire lawn was treated, the grass was found to be free from the

insects as much as two months after a single application of spray had been made. The spray caused no injury to the turf and, where treatment was applied before serious injury had taken place, the bare patches of the lawns were quickly covered by a new growth of grass.

When applied as recommended the materials employed in this treatment cost $3.40 per 1,000 square feet.

The depletion of local supplies of nicotine sulphate and the desirability of a less costly method of control necessitated further work on the problem and it was found that an almost equally good control could be obtained by the use of carbon bisulphide emulsion. The emulsion was prepared as follows :—

Carbon bisulphide	½ pint
Coconut oil	½ pint
Common soap	1½ lb.
Water	10 galls.

In making the emulsion it is convenient to employ a strong soap solution of known strength previously prepared in bulk. The soap solution is placed in a wooden tub and agitated thoroughly while the oil and the carbon bisulphide are added slowly. Emulsification takes place rapidly and the mixture is then diluted to the requisite degree with water.

Before applying the emulsion, the lawn to be treated should be thoroughly watered until the surface soil is saturated. The dilute emulsion is then applied from an ordinary watering-can at the rate of 100 gallons per 1,000 square feet.

Even when applied in considerably greater quantity, this preparation did not injure the grass. Carbon bisulphide emulsion is perhaps somewhat less effective as a control than is nicotine and soap, but eighteen hours after treatment careful search only revealed at most one or two survivors in 50 square feet of lawn. It is possible however, that a second application may be necessary in severe cases in order completely to eradicate the pest. This emulsion also drove numerous mole crickets (*Scapteriscus vicinus* Scudder) to the surface, where they died almost immediately. The cost of materials required for treatment with carbon bisulphide emulsion as described is $2.73 per 1,000 square feet. The object of reducing the cost of chinch bug control is thus only partially attained by the use of carbon bisulphide emulsion, but this method possesses the advantage of requiring only materials which are readily obtainable in the Colony.

Summary.

An account is given of experiments on the control of the chinch bug infesting lawns of savanna grass (*Axonopus compressus*) in Trinidad. Emulsions of lubricating and fuel oils, diluted pyrethrum extract and dusts of nicotine and derris, of the types locally available, were ineffective. A preparation of nicotine and soap and an emulsion of carbon bisulphide were found to control the pest, but both are somewhat expensive. Details of the preparation of these liquids are given.

Acknowledgements.

The writer is indebted to Mr. T. E. K. Potter, D.I.C.T.A., and to Mr. R. E. Dean, Curator of the Royal Botanic Gardens, Port-of-Spain, for valuable assistance rendered in the experimental work.

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MAGNESIUM DEFICIENCY IN FRUIT TREES.

T. Wallace (J. Pom. & Hort. Sci., 18, 145 ; 1940) reports investigations on the magnesium status of leaves from various fruit plants growing in orchards on different soils. Symptoms of magnesium deficiency in apples, black currants, gooseberries and plums were accompanied by low magnesia in the leaves. The importance of the base status is stressed. Data for healthy apple leaves show calcium oxide between 1.5 and 2.4, magnesium oxide 0.42-0.49 and potassium oxide 1.1-1.9 as percentages of the dry weight. Minimum values for magnesia and potash consistent with health are given as 0.4 and 1.0 per cent. respectively. Symptoms of magnesium deficiency did not appear in conditions of potash deficiency. Leaves showing no symptoms at a given potash level showed definite symptoms when the potash content was raised, though no significant change in magnesium content occurred. Magnesium requirements were increased when liberal dressings of potash were given. Magnesium deficiency may occur in conditions of high or low lime. In the former case, dressings of kieserite or Epsom salts are advised, and in the latter, magnesian limestone. In the same journal (p. 119), E. B. Kidston, *et al.*, describe symptoms of magnesium deficiency in apple leaves in the Nelson district of New Zealand. Appearance of the symptoms, brown blotching between the veins and premature defoliation, were prevented by injections of magnesium sulphate. The deficiency symptoms were most severe where liberal use of potassic fertilizers had been made. High potash in the leaves was correlated with low magnesia. On leached acid soils, magnesium deficiency is presumed to be due to an unfavourable ratio of available potash to available magnesium.

THIRD WEST AFRICAN AGRICULTURAL CONFERENCE.*

THE papers read at the Third West African Agricultural Conference held in Nigeria in June 1938 have just been published in a volume of some 650 pages. The Proceedings, consisting of sub-committee reports and resolutions and accounts of discussions on various subjects, form a separate smaller volume of 90 pages, and may fairly be said to be mainly of local administrative interest and importance. But the Papers contain much material which, in view of the paucity of data derived from scientific field experiments in the tropics, must be of the greatest importance and interest to all workers in agriculture and its allied sciences in the Tropics. It therefore seems regrettable that on the cover of the volume of Papers no price is mentioned. The Papers were printed by the Government Printer in Lagos, Nigeria, and no doubt that Government will be reasonably generous in providing copies to agricultural departments and similar institutions in the Tropics. But one still regrets that the volume of Papers is not offered for sale.

The Papers cover all parts of the work of the West African Agricultural Departments, ranging from such scientific subjects as "The Maintenance of Soil Fertility" to such matters as "Education and Agriculture" and "Produce Inspection". Probably the many papers dealing with the soil nutrients in West African soils, and the numerous field and laboratory investigations bearing on the maintenance of soil fertility, are the most interesting to those in other parts of the Tropics.

In all the West African colonies, the soils tend to have a high degree of acidity; but it seems that this is seldom a limiting factor, or even a very adverse factor there, as long as the pH value is not below 5.5. There is a considerable mass of evidence obtained from several different angles of approach that the controlling factor in the fertility of West African soils is almost invariably the content of available phosphate. A response seems seldom or never to be obtained in West Africa from potash manuring in spite of the fact that chemical examination indicates that the supply of available potash is generally relatively low, considerably below, for instance, what is regarded as the limit of sufficiency in Trinidad. The return from manuring with artificial nitrogenous manures alone is often non-existent or negligible; and it is often small, even when the supply of available phosphate is simultaneously increased by manuring. Remarkable returns are obtained from applications of very small quantities of farm yard manure, and results are quoted which leave no room for doubt that green manuring increases the subsequent crop whenever the soil is good enough to grow a green manure crop. The organic matter contents of the soils are generally very low; but in West Africa, as elsewhere in the Tropics, there is, in spite of many experiments bearing on the subject, little or no evidence that the addition of organic matter as such has commonly any very important effect on the fertility of the soil—presumably because the rates of decomposition of organic matter and of nitrification are both very rapid under tropical conditions. But, on the other hand, there is a considerable volume of evidence of various kinds, in several of the Papers, to the effect that both farm yard manure and green manures should in West Africa be regarded as essentially phosphatic manures. It seems clear that they increase the crop primarily, or even strictly in proportion, as they add to the supply of more or less readily-available phosphate in the soil.

It is of interest to compare these general findings about soils and fertility in West Africa with the situation in the West Indies, which has been established by the researches of Professor Hardy and other workers in this field. In the West Indies, as in West Africa, organic matter as such (that is apart from the mineral contents of any organic material that may be added to the soil) seems to play a relatively minor part in fertility as compared to its rôle in wet temperate climates. In Trinidad, as in West Africa, the circumstances in which artificial nitrogenous manures lead to a considerable increase in the crop are much more exceptional than in temperate climates, although it happens that the sugar-cane crop, one of the exceptions in question in the West Indies, is of great importance. Soils which are so rich in mineral nutrients that manuring with artificial mineral manures generally leads to little or no increase in crop, are almost unknown in West Africa, but are to be found in some places in the West Indies. Phosphorus is most commonly the limiting factor, or the most important element in manuring, in the West Indies as in West Africa. In the West Indies again, it is frequently the case that potash manuring gives no beneficial result, but this is not invariably the case, as it seems to be in West Africa. There is, for instance, a fairly large class of soils in Trinidad in which a potash deficiency must be made good if phosphatic manuring is to have its maximum effect. On the whole, therefore, it may be said that the differences in the general position in these matters between the West Indies and temperate regions are of the same nature as those between West Africa and the temperate zone, but are rather less extreme and universal. Climatically, the West Indies may be regarded as lying between West Africa and temperate climates, but nearer to the former than to the latter.

* Third West African Agricultural Conference, 1938, Vol. I, Papers: Nigeria, pp. 519, Gold Coast, pp. 125; Sierra Leone, pp. 12, Vol. II, Proceedings pp. 90.

There is, however, one difference between the figures recorded in these papers and the results of research in the West Indies, which is difficult to understand. The figures for available phosphate and potash in West African soils seem low by West Indian standards. It is possible that there are important actual differences both in the general order of the quantities of available nutrients in the soils, and of the "limits of sufficiency" in the two areas. The geological origins of the soils and the climates of the two areas could perhaps suffice to explain considerable differences both in "available contents" and in "limits of sufficiency". But the recorded differences seem too big to be fully explained in these ways, and it must be recognised that they may be partly due to differences in laboratory technique, until the effect of this factor has been definitely eliminated or closely evaluated by very careful comparisons of the methods used in the two countries, as applied to identical samples.

Another subject which is dealt with in several papers is that of stock rearing, cattle rations and similar problems of animal husbandry. These provide data which should be of interest and utility in every tropical colony which is undertaking work in this direction. The papers record much practical experience as well as many experimental investigations. In regard to rations, it is of interest to note that in Nigeria, as in other tropical countries, the main difficulty is to supply the right amount of protein. If a ration contains enough digestible protein for the cattle it will almost inevitably provide a sufficiently high calorific value. The solution of the problem of a cheap food sufficiently rich in protein has hardly yet been solved, even in Northern Nigeria where an ample supply of ground nut haulms helps in the solution of the problem. It is hoped to meet this difficulty by the use of sweet potato vines, pigeon peas and green gram. Soya beans would, of course, solve it if a variety could be found which would give a fair yield per acre regularly in local circumstances.

The field experiments in semi-arid Northern Nigeria, on which the mixed farming systems advocated by the department there is based, are gradually being extended to the wetter, more typically tropical, South, whence equally instructive results will doubtless emerge in due course. The experiments in the North have covered almost every aspect of animal husbandry in the broadest sense—which crops give the best return for manuring, the most efficient quantity of manure to apply, the residual effect from manure, the extent to which different crops exhaust the soil, the best order of rotation of the different crops, as well as the feeding and management of the cattle themselves. "Some preliminary investigations in the fly population of stable manure heaps" by G. S. Cotterell deal with yet another problem of tropical mixed farming, which seems urgently to call for much more investigation than it has yet received in the tropics.

O. T. F.

MYCORRHIZAL HABIT IN THE DATE PALM (*PHOENIX DACTYLIFERA* LINN.)*

The date palm grows in Egypt in a great variety of soils and conditions. I have seen palms even growing on the seashore of the Gulf of Suez in places which are occasionally flooded with sea-water and where the *pH* of the soil ranges from 8 to 9. It was thought worth while to test the presence or absence of mycorrhiza in such a widely distributed plant.

In the preliminary tests carried out about two years ago, it was found rather difficult to get satisfactory material from old palms, owing to the nature of root growth. However, I started to raise plants from seeds and examined their roots at intervals. It has been found that roots of seedlings up to eight months old and grown in the sandy garden of the Faculty of Science, Abbasieh, are free from mycorrhizal association. At such a stage, marked swellings are recognised at the tips of some roots, and on their examination, they have been found to contain no fungus. Nevertheless, in plants 15 months old and grown in pots containing Nile silt, the mycorrhizal association is quite visible. Infected roots become hypertrophied, relatively more thickened and more opaque than the non-infected. They sometimes stimulate coralloid roots.

The association is of the vesicular-arbiscular type. The extra-matrical mycelium is easily observed, and is of the usual type. Root hairs are absent. The invading hypha forms a sort of appressorium before penetration. It is sometimes developed between the epidermal cells, and it is also found directly opposite their outer walls. After invasion of the thick outer cellulose wall, the fungus proceeds through the cell cavity. It then develops in a very characteristic spiral fashion through a radial row of cortical cells 3–4 layers deep. After that it spreads laterally and inwardly for 3–4 layers, producing these spirally-coiled hyphae within the cells. Then it ramifies in the cortex, producing intra- and inter-cellular mycelia and developing vesicles and arbuscules. Vesicles differ in shape and size, and they may be inside the cells or between them. Arbuscules chiefly develop in the mid-cortex and in the deeply seated layers. In good material the whole of the cortical cells and the inter-cellular spaces with the exception of the outermost 4–6 layers and the two layers next to the endodermis, are seen to be packed with the fungus.

Cultivation of the fungus and its cytological characters are under investigation.

* A letter by Younis Sabet, Botany Department, Faculty of Science, Abbasieh, Cairo, reprinted from *Nature*, Vol. 145, No. 3681, pp. 782-83, 1940.

CHEMICAL NOTES.

(Compiled by the College Department of Chemistry and Soil Science.)

Soil Toxins.*

Reference was made in the *Report of the Progress of Applied Chemistry* for 1937 to the discovery in South Dakota of soils containing sufficient selenium to render plants toxic to animals. Recent work has shown that selenium poisoning is fairly widespread in the semi-arid regions of the United States, and has thrown considerable light on the factors rendering soil selenium available to plants and therefore liable to poison animals. A definite relationship has been established between the occurrence of certain seleniferous plants and soil types (mainly shales), but none between the selenium content of a soil and the liability of stock pasturing on it to be poisoned. There is, however, a close correlation between the selenium content of the soil and of the parent material, and it is considered doubtful whether ordinary weathering processes have any effect in converting selenium occurring naturally in soils into an available form. In soils and rocks, selenium occurs in three forms unavailable to plants, namely, free selenium, pyritic selenide, and basic ferric selenites. It may also be present in available form as selenate, or organically combined, in which case it is subject to eluviation. This explains the low selenium content and toxicity of plants grown on highly seleniferous soils in humid and irrigated areas. Unavailable selenium is made available to forage plants chiefly through the agency of so-called "converter plants" *i.e.* certain species, such as *Astragalus racemosus* and *Stanleya bipinnata*, which occur characteristically on seleniferous soils and are capable of absorbing selenium unavailable to other plants. When the converter plants humify, the selenium is returned to the soil in organic combination available to plants, which may then cause poisoning in animals that eat them. Animals usually avoid converter plants, but where these occur in dense patches, it is often found that ordinary forage plants (which animals will eat) growing near the converters are toxic. Where a thin layer of non-seleniferous surface soil overlies a seleniferous subsoil, roots of converter plants may penetrate the latter and bring up a supply of available selenium into the surface soil which, although apparently free from the element, may thus carry a toxic vegetation. In New Mexico, a toxic area was rendered largely innocuous to livestock by removal of the unpalatable converter plants (*Astragali*).

Earlier anticipations that selenium toxicity could be obviated by applying sulphur to the soil have not been realised. That an antagonism undoubtedly exists between sulphates and selenates has been shown by pot experiments, but under natural conditions, available selenium is almost entirely in organic combination, in which form its absorption by plants is unaffected by sulphur.

* Copied from *Reports of the Progress of Applied Chemistry*, Society of Chemical Industry, England, Vol. XXIV, 1939; Section on "Soils and Fertilizers" by G. V. Jacks. The references to literature have been omitted.

* * *

Availability of Fixed Potassium to Plants.—*L. Kolodny and W. R. Robbins. New Jersey Agricultural Experiment Station.*

This problem was investigated by growing tomato plants in sand cultures in some of which potassium fixed by bentonite was used as the sole source of this element. For comparison, other sources of potassium were used, including exchangeable potassium, potassium of untreated bentonite, and soluble potassium salts. Nutrients other than potassium were supplied as soluble salts. The growth responses, green and dry weights, and the potassium contents of the plants in each treatment were determined as evidences of potassium availability. Each culture consisted of a 6-inch nonporous porcelain glazed pot with 1,600 gm. of white quartz sand in which was incorporated the bentonite sample. The incorporation of the bentonite in the sand was done by mixing the sample with a sufficient quantity of the nutrient solution to form a thick but fluid suspension, which was then thoroughly mixed with the sand. The drainage hole in the bottom of the pot was covered with a small watch glass and then with 250 gm. of washed fine quartz gravel to facilitate free drainage. The sand employed was thoroughly washed with water and successively leached with 5 per cent. hydrochloric acid, with 5 per cent. ammonium hydroxide, and with distilled water. Tomato plants were grown in sand cultures to study the availability of fixed potassium as compared with exchangeable potassium, and to compare the availability of these sources of potassium with that present in untreated bentonite, and as a constituent of a complete nutrient solution. Fixed potassium consisted of that potassium undisplaceable by calcium ions after the alternate wetting and drying of potassium-saturated Wyoming bentonite. Exchangeable potassium was prepared by saturation of the untreated bentonite with potassium. The following is a summary of the more important results: Fixed potassium was utilizable by tomato plants to but a slight extent for growth: Fixed potassium was not nearly so readily available to tomato plants as was exchangeable potassium or the potassium of untreated bentonite: Fixed potassium became available to the tomato plants to a slight extent, apparently by means of root action, perhaps either by carbonic acid excretion or by means of direct contact exchange between roots and the bentonite sample containing this form of potassium.—(*Soil Science*, 1940, Vol. XLIX, No. 4, p. 303.)